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Japan Patent Office Yasuo IMAI (Sealed)

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[List of Submitted Documents]	
[Title of Document]	Specification 1
[Title of Document]	Drawings 1
[Title of Document]	Abstract 1
[Proof Required]	Yes

[Title of Document] Specification

[Title of the Invention] Shape of Wire Loop, Semiconductor Device Having Same, Wire Bonding Method and Semiconductor Manufacturing Apparatus

[Claims]

[Claim 1] A shape of a wire loop comprising a wire connecting a first bonding point and a second bonding point therethrough, characterized in that:

a top portion of a ball bonded to said first bonding point is crushed together with a part of said wire.

[Claim 2] The shape of a wire loop as defined in claim 1, wherein the top portion of said ball bonded to said first bonding point is crushed by a capillary.

[Claim 3] The shape of a wire loop as defined in claim 1 or 2, wherein the wire loop is formed by:

a first step of bonding the wire to said first bonding point;

a second step of carrying out loop control to move said capillary horizontally and vertically;

a third step of bonding the wire to a top or the vicinity of the top of a ball bonded to said first bonding point; and

a fourth step of moving said capillary to said second bonding point by carrying out loop control to move said capillary horizontally and vertically while delivering the wire from said capillary, and then bonding the wire to said second bonding point.

[Claim 4] The shape of a wire loop as defined in claim 3, wherein said second and third steps are repeatedly carried out "n" times ("n" is equal to 1, 2, 3,...) to form the shape of the wire loop.

[Claim 5] A wire bonding method for bonding a wire between a first bonding point and a second bonding point, characterized in that:

the method comprises:

a first step of bonding the wire to said first bonding point;

a second step of carrying out loop control to move said capillary horizontally and vertically;

a third step of bonding the wire to a top or the vicinity of the top of a ball bonded to said first bonding point; and

a fourth step of moving said capillary to said second bonding point by carrying out loop control to move said capillary horizontally and vertically while delivering the wire from said capillary, and then bonding the wire to said second bonding point.

[Claim 6] The bonding method as defined in claim 5, wherein said second and third steps are repeatedly carried out "n" times ("n" is equal to 1, 2, 3,...).

[Claim 7] A semiconductor manufacturing apparatus for carrying out a bonding method of claim 5, characterized in that:

in said fourth step of moving said capillary to said second bonding point by carrying out loop control to move said capillary horizontally and vertically while delivering the wire from said capillary, and then bonding the wire to said second bonding point, the movement of said capillary is automatically controlled by manually inputting height of said capillary to be raised.

[Claim 8] A semiconductor device comprising a wire loop of a shape which includes a wire connecting a first bonding point and a second bonding point therethrough, characterized in that:

the shape of said wire loop is so formed that a top portion of a ball bonded to said first bonding point is crushed together with a part of said wire.

[Claim 9] The semiconductor device as defined in claim 7, wherein the shape of the wire loop is formed by:

a first step of bonding the wire to said first bonding point;

a second step of carrying out loop control to move said capillary horizontally and vertically;

a third step of bonding the wire to a top or the vicinity of the top of a ball bonded to said first bonding point; and

a fourth step of moving said capillary to said second bonding point by carrying out loop control to move said capillary horizontally and vertically while delivering the wire from said capillary, and then bonding the wire to said second bonding point.

[Claim 10] The semiconductor device as defined in claim 8, wherein said second and third steps are repeatedly carried out "n" times ("n" is equal to 1, 2, 3,...).

[Detailed Description of the Invention]

[0001]

[Technical Field to which the Invention Pertains]

The present invention relates to a wire bonding method for connecting a first bonding point and a second bonding point through a wire, a semiconductor manufacturing apparatus for carrying out the method, a shape of a wire loop and a semiconductor device having a wire loop of such a shape incorporated therein.

[0002]

[Prior Art]

Conventionally, in a process of fabricating a semiconductor device, as shown in Fig. 4(a) or 4(b), wire bonding for connecting a pad 2a or a first bonding point A of a semiconductor chip 2 attached to a lead frame 1 and a lead 1a or a second bonding point Z of the lead frame 1 through a wire 3 has been carried out. Typically, loop shapes of the wire 3 connecting the first and second bonding points include a trapezoidal shape and a triangular shape shown in Figs. 4(a) and 4(b), respectively (see, for example, patent document 1 or 2).

[0003]

The wire loop having a trapezoidal shape shown in 4(a) is formed by a sequence of steps as shown in Figs. 5(a)-5(f). First, as shown in Fig. 5(a), a capillary 4 is lowered and a ball 30 which has been formed at a tip end of the wire 3 is bonded to the first bonding point A.

Then, as shown in Fig. 5(b), the capillary 4 is vertically raised to a point B while the wire 3 is delivered. Thereafter, as shown in Fig. 5(c), the capillary 4 is horizontally moved to a point C in a direction opposite from the second bonding point Z.

[0004]

In general, such an operation of the capillary 4 to be moved in the direction opposite from the second bonding point Z is referred to as a "reverse operation". As a result, the portion of the wire 3 between the points A and C is formed to be inclined and the wire 3 is formed at a part thereof with a kink 3a. The portion of the wire 3 between the points A and C thus delivered will constitute a neck height portion H (or a portion of the wire between 2a and 3a).

Subsequently, as shown in Fig. 5(d), the capillary 4 is vertically raised to a point D while the wire 3 is delivered. Then, as shown in Fig. 5(e), the reverse operation of the capillary 4 is performed again, i.e. the capillary 4 is horizontally moved to a point E in the direction opposite from the second bonding point Z. As the result of this reverse operation, the wire 3 has another inclined portion extending between the points C and E, and a kink 3b is formed at a part of the wire 3.

[0005]

This inclined portion of the wire 3 thus delivered between the points C and E will constitute an upper base portion L (or a portion of the wire between 3a and 3b) of the wire loop having a trapezoidal shape shown in Fig. 4(a). Thereafter, as shown in Fig. 5(f), the capillary 4 is vertically raised to a point F so that the wire 3 is delivered by a length corresponding to an inclined portion S (or a portion of the wire between 3b and 1a) of the wire loop shown in Fig. 4(a). Subsequently, the capillary 4 is lowered to the second bonding point Z via positions f' and f" as shown in Fig. 5(f), so that the wire 3 is bonded to the second bonding point Z.

[0006]

The wire loop having a triangular shape shown in Fig. 4(b) is formed by a sequence of steps as shown in Figs. 6(a)-6(e). Since the wire loop having a triangular shape is not provided with an upper base portion L (or a portion of the wire between 3a and 3b) unlike the wire loop having a trapezoidal shape described above, in forming the wire loop of a triangular shape, the second reverse operation shown in Figs. 5(d) and 5(e) is not conducted. Therefore, in this instance, only one step that corresponds to the steps shown in Figs. 5(d), 5(e) and 5(f) (except for f' and f") is carried out as shown in Fig. 6(d). More particularly, the steps shown in Figs. 6(b) and 6(c) are the same as the steps shown in Figs. 5(b) and 5(c), and after the first reverse operation shown in Fig. 6(c), the capillary 4 is vertically raised to a point F as shown in Fig. 6(d) while the wire 3 is delivered. Subsequently, as shown in Fig. 6(e), the capillary 4 is moved to a positions e' in a manner similar to that shown in Fig. 5(f) via the positions f' and f", with the result that the wire 3 is bonded to the second bonding point Z.

[0007]

[Patent Document 1]

Japanese Patent Application Laid-Open Publication No. 10-256297 (Fig. 6)

[Patent Document 2]

Japanese Patent Application Laid-Open Publication No. 2000-227558 (Fig. 2)

[0008]

[Problem to be Solved by the Invention]

However, in the above-described techniques, in a case where a wire loop is formed without any reverse operation of the capillary in order to make the height of a neck height portion H thereof (or a portion of the wire between 2a and 3a) small and the height of the neck height portion H (or the portion of the wire between 2a and 3a) is reduced to a certain level or below,

the neck height portion H is liable to be damaged in drawing or moving the wire 3 to arrange it in place because of the wire 3 vertically extending from the first bonding point A.

[0009]

The present invention has been made in view of the foregoing disadvantages of the prior art. Accordingly, it is an object of the present invention to provide a shape of a wire loop having a low profile which is stable and of which a neck height portion is hard to be damaged. In addition, it is another object of the present invention to provide a wire bonding method capable of forming said wire loop having such a shape, a semiconductor manufacturing apparatus capable of carrying out said wire bonding method, and a semiconductor device having said wire loop incorporated therein.

[0010]

[Means for Solving Problem]

In order to solve the above-mentioned problem, according to the invention set forth in claim 1, a shape of a wire loop comprising a wire connecting a first bonding point and a second bonding point therethrough is characterized in that: a top portion of a ball bonded to the first bonding point is crushed together with a part of the wire.

[0011]

In this instance, the top portion of the ball bonded to the first bonding point is crushed by a capillary.

[0012]

In a preferred embodiment of the invention, the shape of a wire loop is formed by: a first step of bonding the wire to the first bonding point; a second step of carrying out loop control to move the capillary horizontally and vertically; a third step of bonding the wire to a top or the vicinity of the top of a ball bonded to the first bonding point; and a fourth step of moving the capillary to the second bonding point by carrying out loop control to move the capillary horizontally and vertically while

delivering the wire from the capillary, and then bonding the wire to the second bonding point.

[0013]

In a preferred embodiment of the invention, the second and third steps are repeatedly carried out "n" times ("n" is equal to 1, 2, 3,...) to form the shape of the wire loop.

[0014]

In order to solve the above-mentioned problem, according to claim 5, a wire bonding method for bonding a wire between a first bonding point and a second bonding point is characterized in that the method comprises: a first step of bonding the wire to the first bonding point; a second step of carrying out loop control to move the capillary horizontally and vertically; a third step of bonding the wire to a top or the vicinity of the top of a ball bonded to the first bonding point; and a fourth step of moving the capillary to the second bonding point by carrying out loop control to move the capillary horizontally and vertically while delivering the wire from the capillary, and then bonding the wire to the second bonding point.

[0015]

In this instance, the second and third steps are repeatedly carried out "n" times ("n" is equal to 1, 2, 3,...).

[0016]

According to claim 7, a semiconductor manufacturing apparatus for carrying out said bonding method is characterized in that: in the fourth step of moving the capillary to the second bonding point by carrying out loop control to move the capillary horizontally and vertically while delivering the wire from the capillary, and then bonding the wire to the second bonding point, the movement of the capillary is automatically controlled by manually inputting height of the capillary to be raised.

[0017]

According to claim 8, a semiconductor device comprising a wire loop of a shape which includes a wire connecting a first

bonding point and a second bonding point therethrough is characterized in that: the shape of the wire loop is so formed that a top portion of a ball bonded to the first bonding point is crushed together with a part of the wire.

[0018]

In a preferred embodiment of the invention, the shape of the wire loop in the semiconductor device is formed by: a first step of bonding the wire to the first bonding point; a second step of carrying out loop control to move the capillary horizontally and vertically; a third step of bonding the wire to a top or the vicinity of the top of a ball bonded to the first bonding point; and a fourth step of moving the capillary to the second bonding point by carrying out loop control to move the capillary horizontally and vertically while delivering the wire from the capillary, and then bonding the wire to the second bonding point.

[0019]

In a preferred embodiment of the invention, the shape of the wire loop in the semiconductor device is formed by repeatedly carrying out the second and third steps "n" times ("n" is equal to 1, 2, 3,...).

[0020]

[Mode for Carrying Out the Invnetion]

Now, an embodiment of a semiconductor device 10 according to the present invention will be described hereinafter with reference to Fig. 1, in which like parts or corresponding parts are identified by the same reference character or numeral as those in Fig. 4(a).

In the illustrated embodiment, a wire loop of a wire bonded to a first bonding point A and a second bonding point Z is formed to have a trapezoidal shape in general and includes a neck height portion H (or a portion of the wire between 2a and 3a), an upper base portion L (or a portion of the wire between 3a and 3b) and an inclined portion S (or a portion of the wire between 3b and 1a). The upper base portion L of the wire loop is provided at

the opposite ends thereof with kinks 3a and 3b.

[0021]

Such construction of the illustrated embodiment is approximately the same as that of a conventional semiconductor device. However, in the illustrated embodiment, a crushed part 3c is formed in the wire in the vicinity of the first bonding point. As the wire loop has the crushed part 3c thus formed, the kink 3a is stably deformed, resulting in the wire loop having a low profile and exhibiting a strong shape retention.

[0022]

Referring now to Figs. 2 and 3, an embodiment of the wire bonding method according to the present invention by which the semiconductor device 10 shown in Fig. 1 is obtained will be described, wherein like parts or corresponding parts are identified by the same reference character or numeral as those in Figs. 4(a) and 5(a) to 5(f).

Fig. 2 shows a moving path of a capillary 4 and a state of the wire connected to the first and second bonding points. Figs. 3(a) to 3(k) show wire shapes in respective steps in association with the movement of the capillary. As compared to the conventional method for forming a wire loop of a trapezoidal shape shown in Figs. 5(a) to 5(f), the illustrated embodiment of the wire bonding method further includes steps shown in Figs. 3(e) and 3(f) which are carried out between the steps shown in Figs. 5(d) and 5(e). The remaining steps shown in Figs. 3(a) to 3(k) are the same as those of Figs. 5(a) to 5(f), i.e. steps shown in Figs. 3(a) to 3(d) and steps shown in Fig. 3(g) to 3(k) correspond to the steps shown in Figs. 5(a) to 5(d) and the steps shown in Figs. 5(e) and 5(f) (via positions f' and f").

[0023]

First, the steps shown in Fig. 3(a) to 3(d), which are the same as those in the conventional method, will be described. As shown in Fig. 3(a), the capillary 4 is lowered while a clamp (not shown) for clamping a wire 3 and releasing the same is opened, so

that a ball 30 formed on a tip end of the wire 3 is bonded to the first bonding point A. Then, as shown in Fig. 3(b), the capillary 4 is vertically raised to a point B while the wire 3 is delivered. Thereafter, as shown in Fig. 3(c), a reverse operation of the capillary 4 is carried out, i.e. the capillary 4 is horizontally moved in a direction opposite from the second bonding point Z to a point C. As a result, a kink 3a is formed in the wire 3 in the same manner as in the conventional method.

[0024]

Thereafter, as shown in Fig. 3(d), the capillary 4 is vertically raised to a point D1 which may be selected as desired while the wire 3 is delivered. Then, important or characteristic steps of the embodiment of the present invention are performed. More specifically, as shown in Fig. 3(e), the capillary 4 is moved in a direction toward the second bonding point G to a point D2 which is located almost immediately above the first bonding point A and of which the vertical and horizontal positions may be determined as desired. Subsequently, as shown in Fig. 3(e), the wire 3 is bonded to a point M1 by the capillary 4. That is, the wire 3 is bonded to the point which is located almost immediately above the first bonding point A by a second boding operation. As the result of this operation, a crushed part 3c is formed in the wire 3. Then, as shown in Fig. 3(g), the capillary 4 is vertically raised to a point D while the wire 3 is delivered. Thus, in the steps shown in Figs. 3(e) and 3(f), the crushed part 3c is formed in the wire 3.

[0025]

Then, as shown in Fig. 3(h), a second reverse operation of the capillary 4 is performed. That is, the capillary 4 is horizontally moved in a direction opposite from the second bonding point Z to a point E. The movement of the capillary 4 from the point C to the point E forms a kink 3b in the wire 3. Thereafter, as shown in Fig. 3(i), the capillary 4 is vertically raised to a point F so that the wire 3 is delivered by a length

which corresponds to the inclined portion S of the wire 3 (or the portion of wire between 3b and 1a).

[0026]

Subsequently, steps shown in Figs. 3(j) and 3(k) are conducted in the same manner as that in the conventional method described above such that the capillary 4 is lowered to be located at the second bonding point Z, resulting in the wire 3 being bonded to the second bonding point Z. Incidentally, the movement of the capillary 4 from the point F to the second bonding point Z, which is not essential to the subject of the present invention, may be carried out along the same path as that in the conventional method described above, or may be suitably selected from various possible paths.

[0027]

As described above, the second bonding of the wire 3 to the point located almost immediately above the first bonding point A or in the vicinity thereof is carried out as shown in Fig. 3(f), not after the capillary 4 being merely raised as in the step shown in Fig. 3(b). Instead, the second bonding shown in Fig. 3(f) is conducted with respect to the point located almost immediately above the first bonding point A or in the vicinity thereof after the capillary 4 is moved in the direction opposite from the second bonding point Z as shown in Fig. 3(c) and the kink is formed in the wire 3 by performing the steps shown in Figs. 3(d) and 3(e), whereby the crushed part 3c is formed in the neck height portion of the wire. As a result, the neck height portion H is crushed or deformed to have a reduced height which is substantially equal to a height of a flat horizontal portion (a portion of the wire between 3a and 3b) per se, with the result that the wire loop having a low profile can be formed. In addition, since the crushed part 3c of the wire is bonded to the position immediately above the first bonding point A, a rising part of the wire 3 from the first bonding point A is formed to be strong as compared to that of the conventional wire loop, with

the result that a wire loop which is stably positioned and which has a strong shape retention can be formed.

[0028]

Furthermore, in order to control the height of the neck height portion immediately above the first bonding point A or control a damage possibly caused to the neck height portion, the bonding operations shown in Figs. 3(b) to 3(f) with respect to the point immediately above the first bonding point A or the vicinity thereof may be repeatedly carried out twice or more times.

As described above, in the embodiment of the wire bonding method according to the present invention, the bonding operation shown in Fig. 3(b) to 3(f) is carried out at least one time.

[0029]

The shape of the wire loop according to the embodiment of the present invention is formed by the wire bonding method as described above. An embodiment of a semiconductor device according to the present invention has a wire loop or loops of such a shape incorporated therein.

[0030]

[Effect of the Invention]

As can been seen from the foregoing, in the wire bonding method and the semiconductor device according to the present invention, the wire loop connecting the first bonding point and the second bonding point therethrough is provided on the neck height portion thereof with the crushed part which is formed by crushing a part of the wire in proximity to the neck height portion together with the top portion of the ball bonded to the first bonding point. Such construction can provide a wire loop having a low profile which is stable and strong in shape retention. Such a shape of the wire loop can be readily obtained by, after bonding the wire to the first bonding point, raising the capillary slightly, carrying out loop control, and thereafter bonding the wire to a portion or the vicinity of the portion

bonded to the first bonding point.

Therefore, not only a wire loop having a short wiring distance but also a wire loop having a long wiring distance can be obtained as a stable wire loop having a low profile. In addition, the wire loop thus formed has a strong shape retention which withstands a force or pressure exerting on the wire loop from outside, to thereby prevent bending or tilting of the wire and a breakage in the neck height portion of the wire loop which are caused by an external force or pressure. More particularly, the wire loop can perform an excellent shock absorbing function against a shock, such as a shock caused by contact of the capillary or emission of an ultrasonic wave during bonding the wire to the second bonding point, vibration of the wire, an external force generated by flow of a molding material during injection of the molding material and the like, with the result that bending or tilting of the wire and a breakage in the neck height portion of the wire loop can be effectively prevented.

[Brief Description of the Drawings]

[Fig. 1]

Fig. 1 is an schematic view showing a shape of an embodiment of a wire loop in a semiconductor device according to the present invention.

[Fig. 2]

Fig. 2 is a schematic view showing a moving path of a capillary to form the wire loop having a shape shown in Fig. 1 and a state of connection of the wire.

[Fig. 3]

Figs. 3(a) to 3(k) are schematic diagrams showing wire shapes in respective steps in association with the movement of the capillary according to a method of the present invention.

[Fig. 4]

Figs. 4(a) and 4(b) are schematic views showing conventional wire loops having a trapezoidal shape and a triangular shape, respectively.

[Fig. 5]

Figs. 5(a) to 5(f) are schematic diagrams showing wire shapes in respective steps in association with the movement of the capillary to form the wire loop of a trapezoidal shape shown in Fig. 4(a).

[Fig. 6]

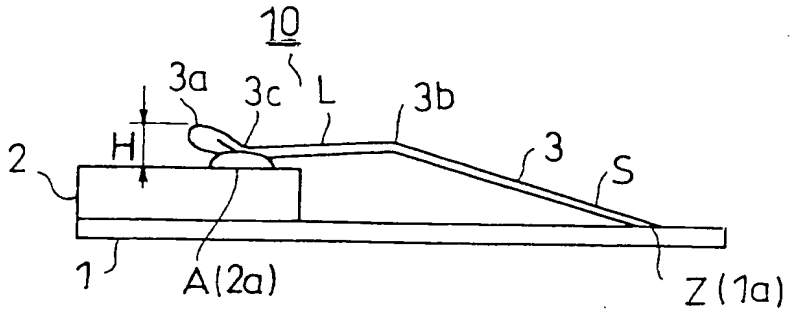
Figs. 6(a) to 6(e) are schematic diagrams showing wire shapes in respective steps in association with the movement of the capillary to form the wire loop of a triangular shape shown in Fig. 4(b).

[Explanation of Reference Characters]

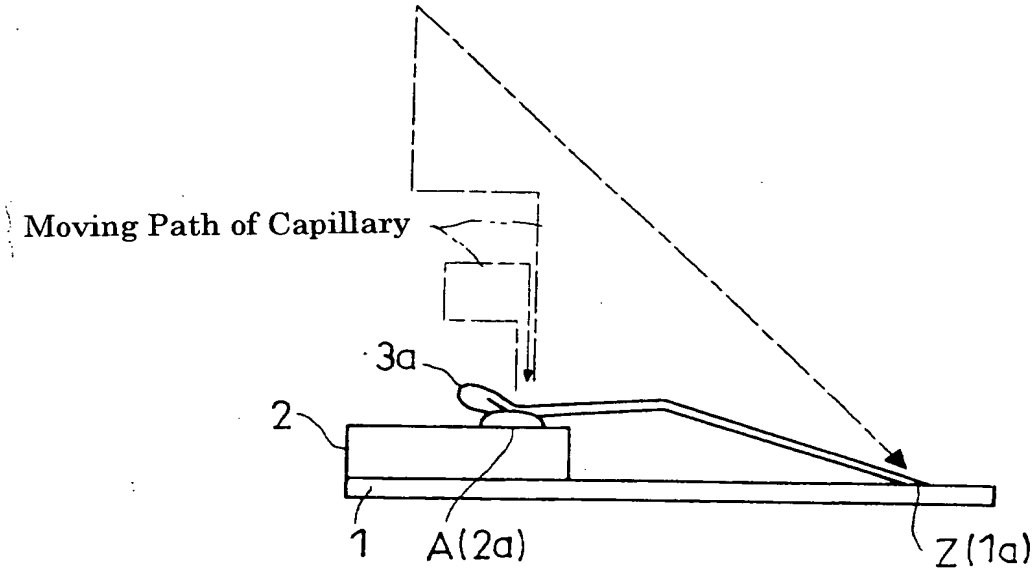
1 Lead frame
1a Lead
2 Chip
2a Pad
3 Wire
4 Capillary
30 Ball
H (2a-3a) Neck height portion
L (3a-3b) Flat portion
S (3b-1a) Inclined portion
A First bonding point
Z Second bonding point

[Title of Document] Drawings

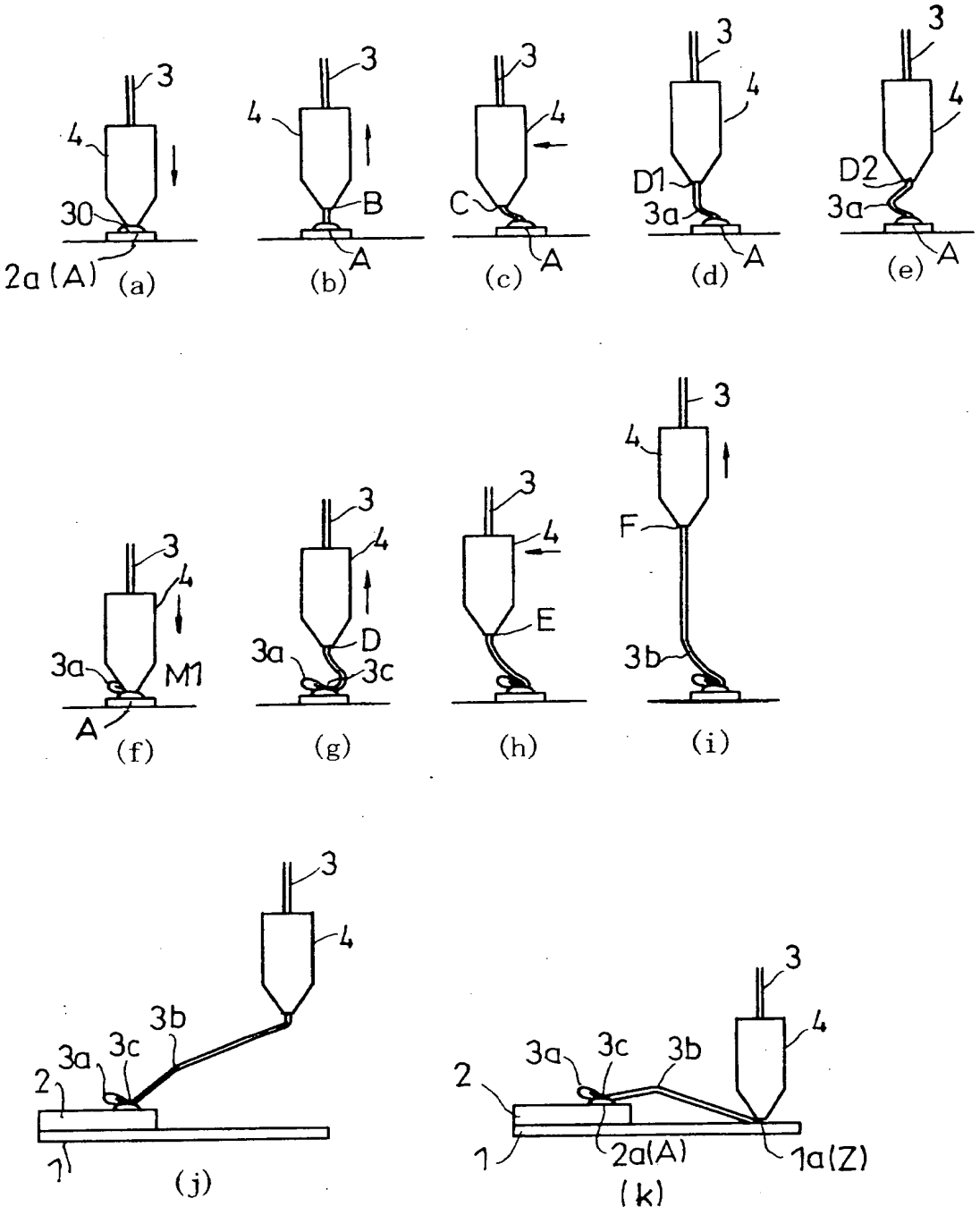
[FIG. 1]



[FIG. 2]



[FIG. 3]


3
4
30
2a (A)
(a)
B
A
(b)
C
A
(c)
D1
3a
A
(d)
D2
3a
A
(e)
M1
A
(f)
D
3a
3c
(g)
E
(h)
F
3b
(i)
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3c
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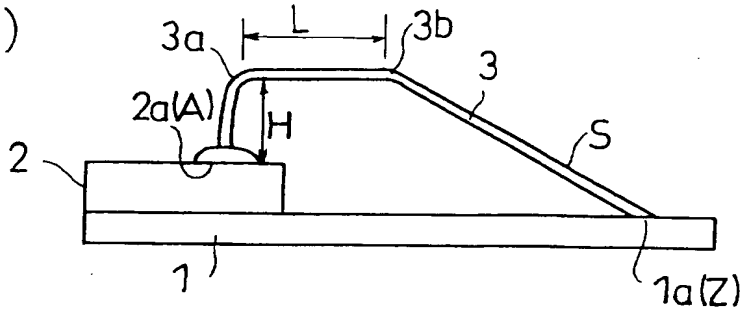
1a(Z)
(k)

[FIG. 4]

(a)



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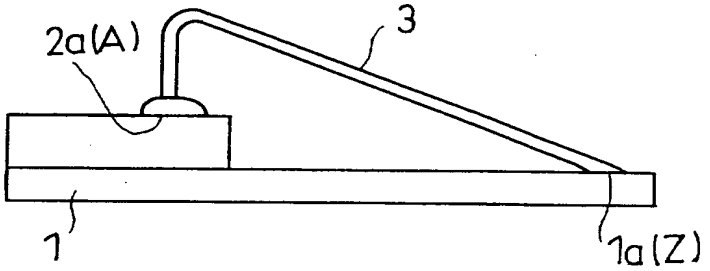

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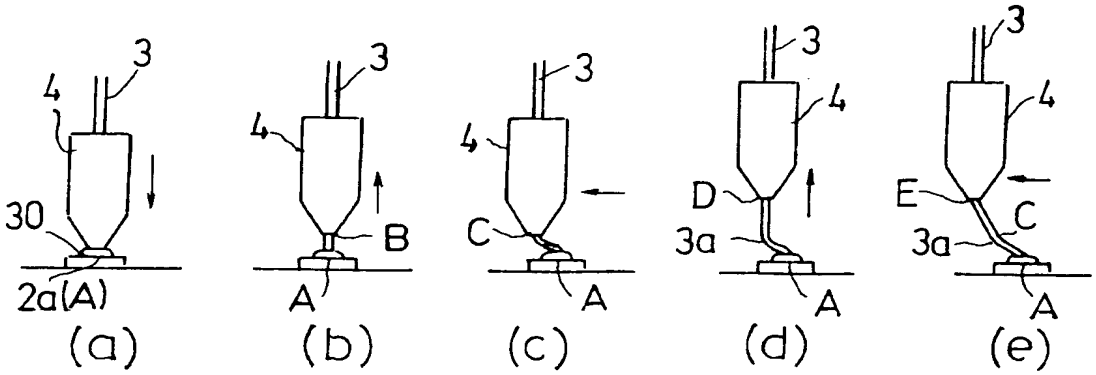
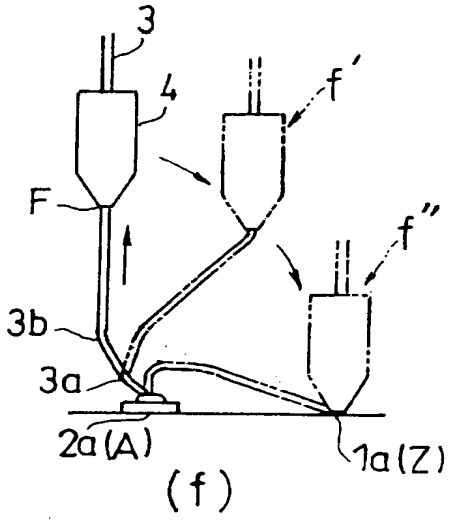
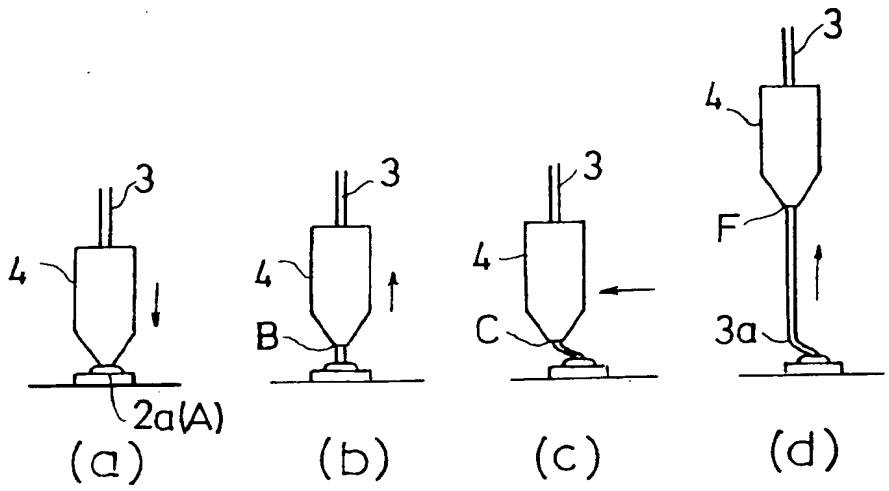
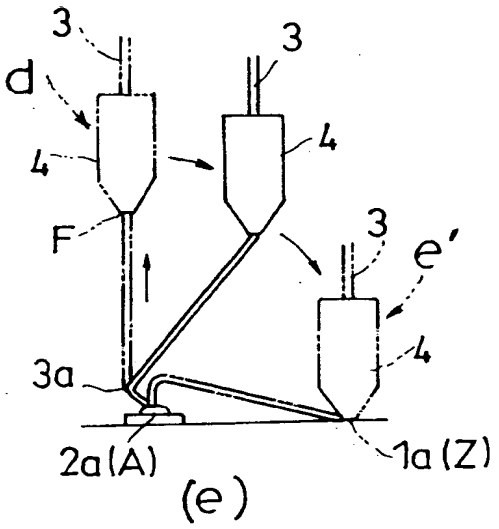




[FIG. 6]





[Title of Document] Abstract

[Abstract]

[Problem to be Solved by the Invention] To provide a shape of a wire loop having a low profile which is stable and of which a neck height portion is hard to be damaged, a wire bonding method, a semiconductor manufacturing apparatus for carrying out the method, and a semiconductor device having said wire loop incorporated therein.

[Means for Solving Problem] A wire loop comprises a wire connecting a first bonding point and a second bonding point therethrough, and has such a shape that a top portion of a ball bonded to the first bonding point is crushed together with a part of the wire. The wire loop is formed by a wire bonding method which includes: a first step of bonding the wire to the first bonding point; a second step of carrying out loop control to move the capillary horizontally and vertically; a third step of bonding the wire to a top or the vicinity of the top of a ball bonded to the first bonding point; and a fourth step of moving the capillary to the second bonding point by carrying out loop control to move the capillary horizontally and vertically while delivering the wire from the capillary, and then bonding the wire to the second bonding point.

[Elected Figure] Fig. 1

VERIFICATION OF TRANSLATION

I, the below named translator, hereby declare that:

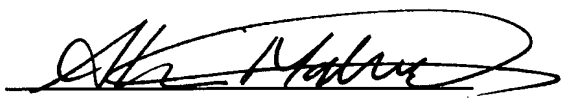
My name and post office address are as stated below:

That I am knowledgeable in the English language and in the language in which the below identified Japanese application was filed, and that I believe the English translation of the Japanese Patent Application No. 2002-338296 is a true and complete translation of the above identified Japanese application as filed.

I hereby declare that all statements made herein are true and that all statements made on information and belief are believed to be true.

Date: February 17, 2005

Full name of the translator: Akinori MATSUBARA

Signature of the translator: 

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